Leveraging Water Window Developments for 13.5-nm Sources.

Fergal O'Reilly[1,2], Kenneth Fahy[1], Tony McEnroe[1], Jason Howard[1], Padraig Dunne[2], Emma Sokell[2], Ronan Byrne[1], Aodh O'Connor[1] Carmen Vela-Garcia[2] and Paul Sheridan[1].

[1]SiriusXT Ltd., Science Centre North, UCD, Belfield, Dublin 4, Ireland
[2]School of Physics, UCD, Belfield, Dublin 4, Ireland

Email: *info@SiriusXT.com* **Web:** *www.SiriusXT.com*

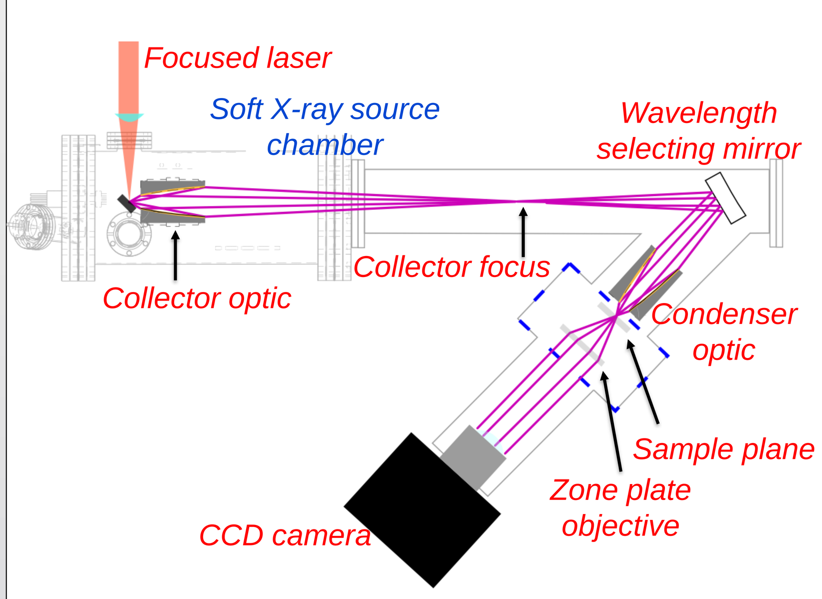
Introduction

We have recently reported on the development of a compact lab based microscope that aims to deliver synchrotron performance in a system that will turn cryo-SXT into an affordable, efficient laboratory tool, thus increasing the scope and throughput of possible research projects. The key to this has been the development of a sufficiently bright and compact source of soft X-rays in the "Water Window" region of the spectrum between 2.4 & 4.4 nm. In this poster we show data on light source performance and calculate the efficiency of the same technology when deployed as a source of EUV radiation at 13.5 nm ±1% bw. This source would have an application in EUV actinic metrology.

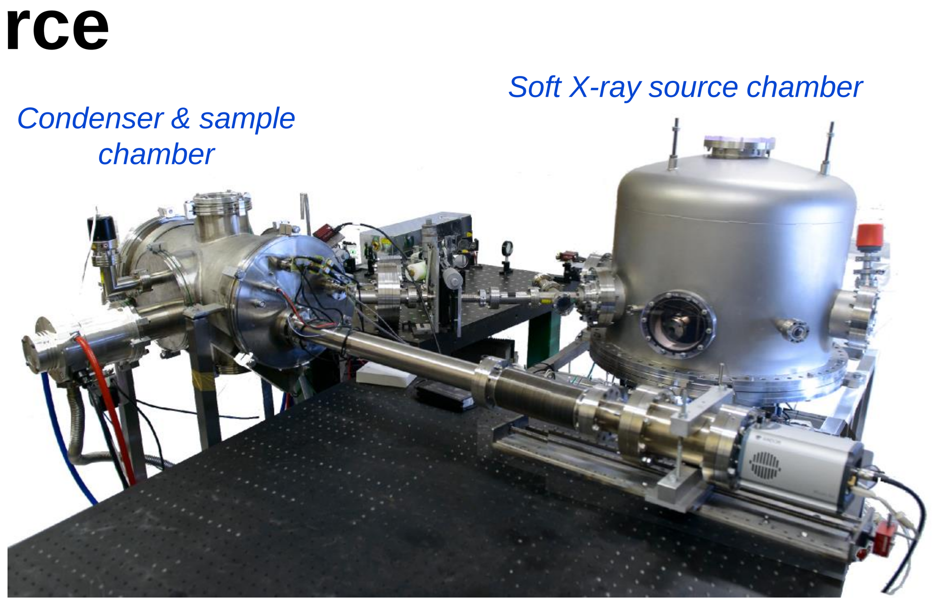
Our Technology

The key technology at the core of the SiriusXT instrument is a high-performance soft X-ray light source based on laser-produced plasma emission with the appropriate size, wavelength and brightness, combined with smart optics whose optical quality is not degraded by the debris generated by the plasma. This unique combination enables the deployment of a lab-scale stable and robust light source suitable for cryo-SXT. The technology works by focusing a high power pulsed laser onto a solid target made from appropriate metals, producing a tiny million degree plasma. This laser plasma is hot enough to emit soft X-rays sufficient for efficient cell imaging, but it also produces a lot of metal debris. Delicate optics are required to collect the soft X-rays for use in the microscope and for focusing the laser, and these would be very quickly destroyed by the debris from the plasma. The company has developed self–healing soft X-ray and laser focusing optics, which means that the optics can last indefinitely even in these extreme conditions.

Brightest Lab Light Source

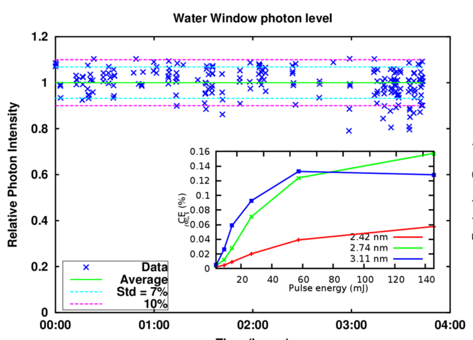


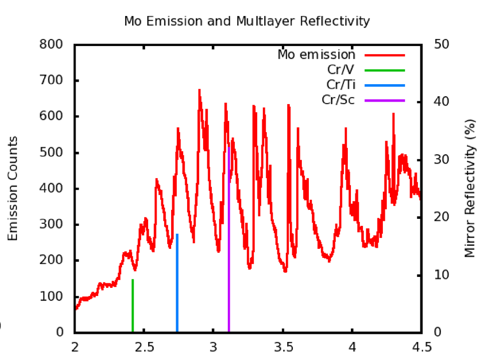
SiriusXT microscope schematic.



SiriusXT prototype microscope.

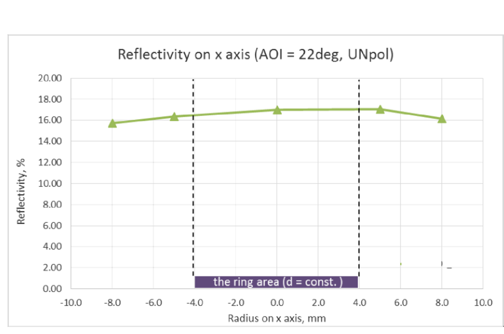
- Key technology is self-healing plasma-robust optics in front of a high average power laser
- Output stable for > 1 year of operation





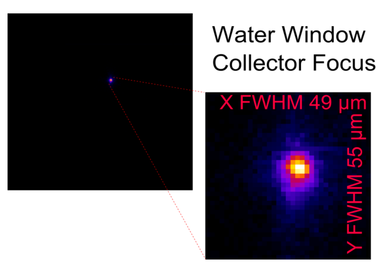
Highest Performance Optics

Highest Reflectivity WW Multilayer 17% Unpolarised at 2.42 nm – measured at synchrotron

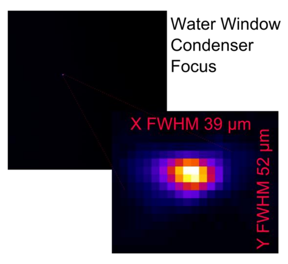


Highest form accuracy ellipsoidal collector and condenser

Liquid coated collector has almost perfect performance



Condenser output – low scattering means fast image time



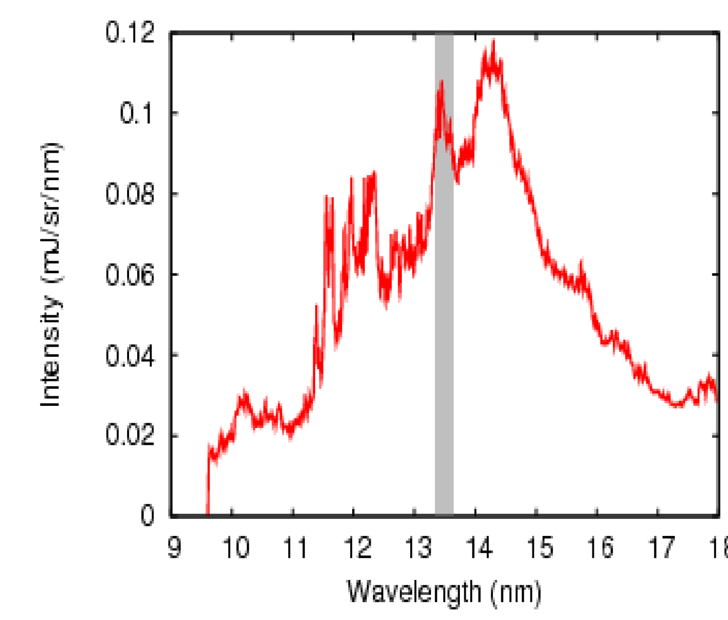
Plasma diameter < 15 µm

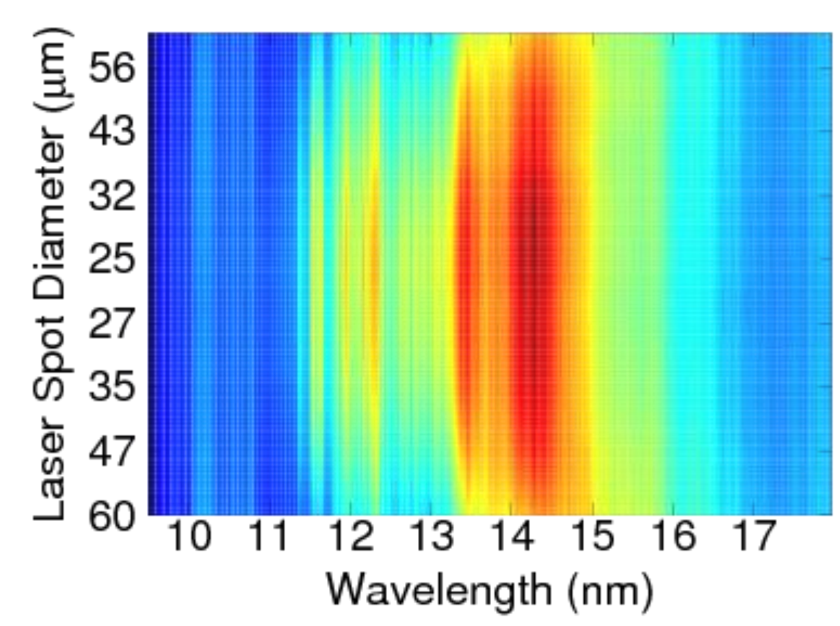
- Source output > 10^{12} 512 eV photons per second in a bandwidth of 0.3%
- High resolution 3D images on 10 micron thick samples in < 1 hour

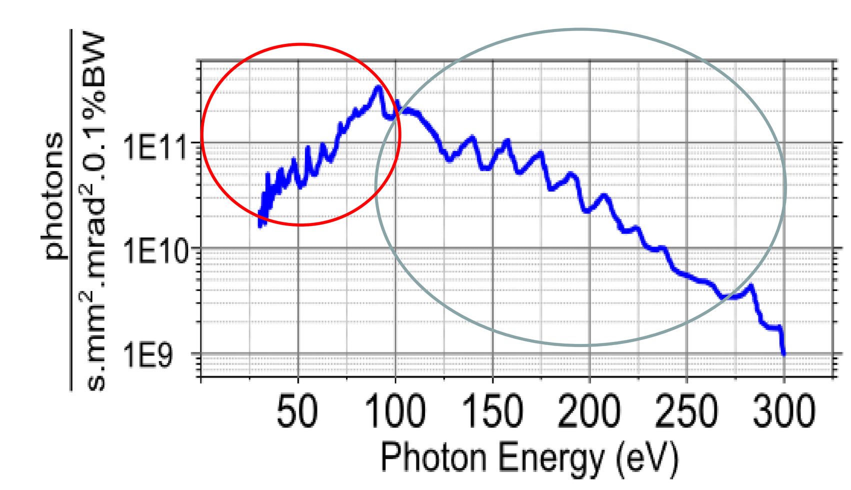
13.5-nm Source

Spectra of GaInSn

(Galinstan)







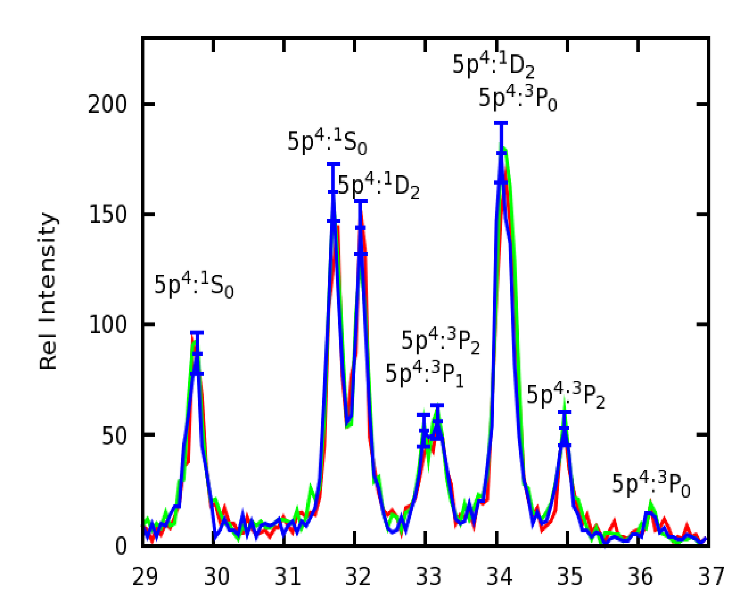
Source Performance

Source input parameters:

LPP Conversion Efficiency 2%,
Optic Collection Efficiency 2%,
Laser Input Power 200 W,
(Nd:YAG, 10 - 40 kHz, 10 ns, 5 - 20 mJ).

Plasma Size 10 – 50 microns.
Source Brightness (range): 2500 to 110 W/mm^2/sr
Etendue (range): 2 × 10^{-5} to 6 × 10^{-4} mm^{2}sr
Plasma and target parameters can be tailored within a range of values.

A Xenon N_{45},OO Auger spectrum acquired using a photoelectron spectrometer coupled to the GaInSn LPP source.
Each spectrum was acquired in ~20 minutes, illustrating the high flux and stability of the source. The electron analyser is a 150º spherical sector analyser operated with a pass energy of 5eV.
The source was coupled to the spectrometer via a double multilayer (Mo/Si) mirror beamline which focused the radiation from the source to a 3x3mm spot at the source point of the electron spectrometer. The spectral profile of the radiation was narrowed by the multilayer to a 3eV FWHM bandpass at 89 eV.



Acknowledgements

The authors would like to thank the staff of the UCD School of Physics and Mechanical Workshop, for their continued contribution to this effort.